Evaluation of Seed Treatments on *Shrunken-2* Sweet Corn

RICHARD E. BAIRD, Department of Botany and Plant Pathology, Purdue University, Southwest Purdue Agricultural Center, Vincennes, IN 47591; CLAUDE NANKAM, PAYAM FALLAH MOGHADDAM, and JERALD K. PATAKY, Department of Plant Pathology, University of Illinois, Urbana 61801

ABSTRACT

Baird, R. E., Nankam, C., Fallah Moghaddam, P., and Pataky, J. K. 1994. Evaluation of seed treatments on *shrunken*-2 sweet corn. Plant Dis. 78:817-821.

Sweet corn seed treatments were evaluated at Vincennes, Indiana and Urbana, Illinois in 1992 and 1993. In 1992, the soil was cool and moist at both locations, and the most prevalent fungi 5 and 10 days after planting (DAP) included *Pythium ultimum, Rhizopus stolonifer, R. arrhizus,* and *Trichoderma* spp. *P. ultimum,* an important pathogen of *sh2* sweet corn, was isolated more frequently 5 DAP than 10 DAP. In 1993, *P. ultimum* was not isolated from seed collected at Vincennes as commonly as were *Trichoderma* spp., *Fusarium moniliforme,* and *Penicillium oxalicum.* Treatments which enhanced stand establishment had the broadest range of activity. Standard fungicide + polymer + priming was the only treatment of 20 for which stands were significantly greater than the untreated, primed control in all four trials. Stands for the standard fungicide, primed metalaxyl, and primed metalaxyl/captan treatments were greater than the primed, untreated control in three of four trials. Solid matrix priming of seed increased stands when added to relatively ineffective fungicide treatments, but priming gave little additional stand improvement when fungicides were effective. Priming improved plant height much more than plant stands. Multicomponent seed treatments including protectant fungicides such as captan/thiram, a broad spectrum systemic with activity against *Fusarium* and *Penicillium* spp., a compound effective against *Pythium* spp., some form of priming, and inert polymer coatings may not be necessary in all environments but may enhance stand and growth of *sh2* seed in certain adverse environments. Unless adverse environments can be predicted, multicomponent seed treatments provide the best protection against poor stands and seedling diseases of *sh2* corn.

Sweet corn (*Zea mays* L.) for fresh market, freezing, and canning is an important commodity in the United States. Sucrose levels of the fresh market *sh2* hybrids can be two to three times greater than standard hybrids with the sugary (*su*) endosperm mutation (15). Because of elevated sugar content, hybrids with the *shrunken-2* (*sh2*) endosperm mutation have continued to replace *su* hybrids. Poor germination, low vigor of seed, and reduced stand establishment have been associated with genetic differences and other factors of *sh2* hybrids compared with *su* hybrids (3,14).

Compared with seed of *su* corn, seed of *sh2* sweet corn is smaller, seed coats are thinner, and kernels are more easily damaged, resulting in increased leakage of electrolytes and carbohydrates (13), particularly during imbibition chill injury (3). Imbibition of water intake at less than 16 C results in transverse cracking of the radicle (4,8). The resulting leakage of electrolytes can stimulate pathogenic soilborne fungi which cause seed rot and seedling blight (11). Also, low carbohydrate levels in *sh2* seed adversely affect germination vigor (15), thereby enhancing the establishment of fungi in seed and seedlings prior to or just after emergence.

Fungicides are commonly applied as seed treatments to improve the stand establishment of *sh2* sweet corn. In a trial in Idaho, captan increased stands of *sh2* lines by as much as 30%, but captan + imazalil improved plant stands over captan alone (16). Thiophanate-methyl and metalaxyl also effectively controlled seed rot and seedling blight (S. K. Mohan, *personal communication*). In another study with over 30 locations in eight states, a seed treatment mixture of captan, thiram, metalaxyl, and benomyl usually was more effective than other combinations at increasing stand establishment (17). Certain fungicides were substituted for others in the optimal treatment with no adverse effect, but omission of a broad-spectrum protectant, a systemic with activity against *Penicillium* and *Fusarium,* or a systemic with activity against *Pythium* reduced efficacy over several locations.

Reducing injury of *sh2* seed by slowing the imbibition of water could effectively lower the incidence of seed rot and seedling blight. One method is physiological disease control using presown hydration (priming) of seed (1). With another method, called osmotic priming or osmotic conditioning of seed, seeds imbibe within an aerated osmotic solution of polyethylene glycol or various salts. Osmotic priming reduced preemergence rot of sugar beet (*Beta vulgaris* L.) seed caused by *Pythium* spp. (2). A third method is solid matrix priming, which includes a combination of seed hydration in a solid-based media and the addition of a biological control agent (10). Solid matrix priming with *Pseudomonas fluorescens* Migula as the control agent was more effective than metalaxyl in controlling damping-off of *sh2* seedlings by *Pythium* spp. in cold soils (3).

Growth hormones (e.g., biostimulators) also have been reported to enhance plant growth and stimulate development of roots and shoots (7). Seaweed extracts containing naturally occurring auxins, cytokinins, and gibberellic acids increased root mass and the root–shoot ratio of several crops (5,6,12). Contrary to those findings, the synthetic biostimulant, cytokinin benzyladenine, did not significantly improve rooting of grass species (7). It is uncertain, however, whether crops such as *sh2* sweet corn can benefit from biostimulants. Also, data are not available on the effects of growth hormones integrated with other treatments, such as fungicides, priming, and polymer coating of seeds.

Polymer coatings such as Ongard may reduce seed coat damage and electrolyte leakage (S. W. Marshall, Asgrow Seed Co., Nampa, ID, *personal communication*). The coatings can be applied separately or in combination with standard fungicides. The polymer coating significantly enhanced plant stands in preliminary studies (Baird, *unpublished*), but additional studies are warranted.

The objectives of this investigation were to evaluate the effect of different seed treatments, including fungicides, biopriming, a polymer seed coating, and biostimulants (growth hormones), separately and in combination, on stand establishment and seedling growth of *sh2* sweet corn, and to determine which fungi predominated on *sh2* seed during early stages of emergence.

MATERIALS AND METHODS

Seed treatments were tested at two locations. The *sh2* hybrid Even Sweeter (Asgrow Seed Co.) was planted on 26 May 1992 and 1993 in a Petrolia silty clay loam soil at the Southwest Purdue Agricultural Center, Vincennes, Indiana

Research supported in part by Asgrow Seed Company, Kalamazoo, MI 49001, and the Agriculture Experiment Station, University of Illinois at Urbana-Champaign, as part of project 68-0323.

Present address of first author: Department of Plant Pathology, University of Georgia, RDC, Tifton 31794. Present address of third author: Department of Plant Biology, University of Illinois, Urbana 61801.

Accepted for publication 6 May 1994.

and on 18 May 1992 and 27 May 1993 in a Drummer silty clay soil at the University of Illinois, Agronomy/Plant Pathology South Farm, Urbana. At Vincennes, the field trials were disked twice, and atrazine was applied at 1.3 L a.i./ha as a preemergent and alachor at 2.1 L a.i./ha as a postemergent. At Urbana, the fields were moldboard plowed, and the preplant herbicides included atrazine at 1.0 L a.i./ha, EPTC at 5.1 L a.i./ha, and cyanazine at 1.8 L a.i./ha. The experimental design was a randomized complete block with four replicates, except the Vincennes trial in 1993, in which there were three replicates. Each experimental unit consisted of two rows about 3.6 m long with 0.76 m spacing between rows and 38 seeds per row. Twenty seed treatments were evaluated (Table 1), including 16 treatments that were part of a 2 × 8 factorial treatment design, and four additional treatments. The factorial included solid matrix primed and nonprimed seed in combination with eight seed treatments: Addamax (growth hormones + nutrient mixture applied at a rate of 0.8 g a.i./kg), chlorothalonil (1.0 g a.i./kg), fluazinam (0.6 g a.i./kg), imazalil (0.1 g a.i./kg), metalaxyl (0.1 g a.i./kg), metalaxyl + captan 400D (0.1 g a.i./kg + 0.4 g a.i./kg), triadimefon (2.4 g a.i./kg), and an untreated control. The Addamax mixture includes the growth hormones (biostimulants) pyridoxine, cyanocabalamin, folacin, and 2,3,4,5 trihydroxypentaneodoic acid + polymeric poly-hydroxy acid. The four additional treatments that were not tested in combination with priming were fluazinam + chlorothalonil (0.6 g a.i./kg + 1.0 g a.i./kg), bacterization using the RB 126 isolate of *Pseudomonas fluorescens* (106 cfu/ml), the standard fungicide seed treatment of Asgrow Seed Co. (which includes thiram, carboxin, captan, metalaxyl, and imazalil), and an inert polymer seed coating, Ongard, in combination with the standard fungicide seed treatment and primed seed. The standard fungicides—thiram, carboxin, captan, metalaxyl, and imazalil—were applied to seed by Asgrow Seed Co. The other seed treatments, Addamax, chlorothalonil, fluazinam, imazalil, metalaxyl, metalaxyl + captan, triadimefon, fluazinam + chlorothalonil, and *Pseudomonas fluorescens* (obtained from tissue of Even Sweeter sweet corn seed) were applied by R. E. Baird using the 1.5% methylcellulose application for the bacterial seed treatment. The solid matrix primed seed treatment was prepared by Kamterter Co. (Lincoln, NE) except the Ongard/standard fungicide treatment, which was primed for Asgrow by Gustafson Inc. (Dallas, TX) using a patented prehydration process. The methods used to apply *Pseudomonas fluorescens* to seed were the same as those used previously (10).

Plant stands were counted at Urbana on 29 May, 3 June, and 9 June 1992 (11, 16, and 22 days after planting [DAP]), and 22 June 1993 (26 DAP). Stand uniformity and height were recorded 11 June 1992 (24 DAP) and 13 July 1993 (47 DAP). At Vincennes, plant stands were counted 5 June, 12 June, and 17 June 1992 (10, 17, and 22 DAP), and on 7 June, 14 June, and 20 June 1993 (12, 19, and 25 DAP). Plant height and stand uniformity were recorded 21 June 1992 (26 DAP) and 28 June 1993 (33 DAP). Stand uniformity ratings, which are measures of stand evenness, were determined as the percentage of plants per plot varying less than 2.5 cm in height from the plot mean (9).

To determine which fungi were predominant in seed and seedlings, four kernels per experimental unit were recovered from both locations at 5 and 10 DAP in 1992 and at Vincennes in 1993. At 10 DAP, seed which had primary roots attached were left intact, and isolations were obtained from both seed and root. Kernels were washed under running water for 5 min to remove all soil and debris, surface disinfected in 0.525% (w/v) aqueous sodium hypochlorite solution for 2 min, transferred onto petri dishes (100 × 15 mm) containing 2% distilled water agar, and incubated at room temperature (24 C) for up to 1 wk. Fungal colonies were subcultured from tissue plated on water agar onto potato-dextrose agar (PDA) (39 g/L of distilled water) and incubated at 24 C for 7 days prior to identification.

Data were analyzed by analysis of variance combined over all trials and for each trial. Treatments were compared by mean separation tests (Bayesian LSD [k = 100]) and by a contrast of six treatments including metalaxyl and 14 treatments without metalaxyl, and by contrast of eight primed and eight nonprimed treatments within the 16-treatment factorial.

Table 1. Effects of seed treatments on stands (%) of *sh2* sweet corn hybrid Even Sweeter planted in Vincennes, Indiana and Urbana, Illinois in 1992 and 1993

		1992		1993		
Seed treatments and contrasts	**Bioprimed**	**Ind**	**Ill**	**Ind**	**Ill**	**Treatment mean**
Ongard/standard fungicide[a]	Yes	79[b]	68	59	57	66
Standard fungicide	No	59	60	48	58	57
Fluazinam/chlorothalonil	No	14	30	12	16	18
Pseudomonas fluorescens	No	12	43	16	26	25
Untreated control	No	18	41	25	32	29
Addamax	No	9	31	22	24	21
Chlorothalonil	No	20	44	18	16	25
Fluazinam	No	28	40	37	23	31
Imazalil	No	2	17	31	15	16
Metalaxyl	No	20	63	27	56	43
Metalaxyl/captan	No	14	34	24	20	23
Triadimefon	No	30	52	25	38	36
Untreated control	Yes	46	51	50	40	46
Addamax	Yes	49	52	36	19	39
Chlorothalonil	Yes	55	50	36	33	44
Fluazinam	Yes	43	53	25	38	41
Imazalil	Yes	52	55	33	11	38
Metalaxyl	Yes	48	56	25	59	48
Metalaxyl/captan	Yes	52	58	49	68	57
Triadimefon	Yes	45	52	21	37	40
Grand mean		35	47	31	34	
Standard deviation		21	12	12	17	
BLSD (k = 100)[c]		9.8	9.1	27.1	15.4	6.5
Contrasts[d]						
No priming		18*[e]	40*	26	28	28*
Priming		49*	52*	34	38	44*
No metalaxyl		31*	43*	28*	26*	32*
Metalaxyl		45*	56*	39*	53*	49*

[a]Standard fungicide treatment applied by Asgrow Seed Company includes thiram, carboxin, captan, metalaxyl, and imazalil.
[b]Mean percentage of plants emerged from 76 kernels planted per replicate with three (Vincennes, 1993) or four replicates.
[c]BLSD for comparison among 20 treatments within years and locations.
[d]Contrasts of eight primed vs. eight nonprimed seed treatments and six treatments including metalaxyl vs. 14 treatments without metalaxyl.
[e]Comparison of contrasts means are significantly different at the 0.01 level if followed by an asterisk (*).

RESULTS

Precipitation at Vincennes was 11.1 and 4.5 cm in May and June 1992, and 11.1 and 3.2 cm in May and June 1993. At Urbana, precipitation was 8.7 and 6.7 cm in May and June 1992, and 4.5 and 15.1 cm in May and June 1993. Air temperatures during the first 10-day

period after planting ranged from 10 to 20 C in 1992 and 6 to 28 C in 1993 at Vincennes, and from 10 to 22 C in 1992 and 6 to 29 C in 1993 at Urbana.

Plant stands. The effects of treatments on plant stands were similar for all sampling dates within a location; therefore, data are presented for the final sampling date, which was at least 21 DAP (Table 1). Stands (%) were relatively low in all trials, which is typical of most seed lots of Even Sweeter. Grand means and standard deviations were 35 ± 21%, 47 ± 12%, 31 ± 12%, and 34 ± 17% for the Vincennes and Urbana trials in 1992 and 1993, respectively. Treatment means ranged from 2 to 79% (Vincennes, 1992), 17 to 68% (Urbana, 1992), 12 to 59% (Vincennes, 1993), and 11 to 68% (Urbana, 1993). Stands for the nonprimed, untreated control were 18, 41, 25, and 32% for the Vincennes and Urbana trials in 1992 and 1993, respectively (Table 1).

Main effects of trials and the treatment × trial interaction were significant in the combined ANOVA, thus treatments were compared within trials. Stands differed significantly among seed treatments in each trial (Table 1). Stands from the Ongard/standard fungicide treatment had the highest mean in three of four trials. Stands from the standard fungicide treatment were not different from the best treatment in three of four trials. Stands from nonprimed metalaxyl and primed metalaxyl/captan treatments were not different from the best treatment in two of four trials. When treatment means were compared over trials, only the Ongard/standard fungicide, standard fungicide, and primed metalaxyl/captan treatments had stands that were significantly greater than the primed, untreated control (Table 1).

Ongard/standard fungicide was the only treatment for which stands were significantly greater than the untreated, nonprimed control in all four trials. Stands for the standard fungicide, primed metalaxyl, and primed metalaxyl/captan treatments were significantly greater than nonprimed untreated control in three of four trials. In all trials, stands were not significantly greater than the nonprimed, untreated control for six nonprimed treatments, including fluazinam/chlorothalonil, *Pseudomonas fluorescens,* Addamax, chlorothalonil, imazalil, and metalaxyl/captan.

The contrast of eight solid matrix primed and nonprimed treatments was significant in the combined ANOVA and in three of four trials (Table 1). Averaged over the eight seed treatments, priming increased stands by 31, 12, and 10% in Vincennes and Urbana in 1992 and in Urbana in 1993, respectively; however, the interaction of priming and seed treatments was significant in each of those three trials, primarily because the effects of priming were considerably greater for seed treatments which had poor stands without priming. For example, in Urbana in 1992, priming did not enhance the stands of the metalaxyl or the tridimefon treatments, which had stands of 63 and 52%, respectively, without priming. However, priming increased stands 10 to 25% for the untreated control, Addamax, fluazinam, and metalaxyl/captan treatments, for which stands ranged from 31 to 44% without priming. Similar interactions were observed for the trials in Vincennes in 1992 and in Urbana in 1993. In the three trials for which the contrast of priming treatments was significant, metalaxyl/captan was the only treatment for which primed seed had greater stands than nonprimed seed. Also, the Ongard/standard fungicide treatment, which included priming, had significantly greater stands than the standard fungicide treatment for the trial in Vincennes in 1992; and means for the Ongard/standard fungicide treatment were higher than or equal to the standard fungicide treatment in the other three trials.

The contrast of treatments with and without metalaxyl was significant in all trials. The average stand of treatments with metalaxyl was 14, 13, 11, and 27% higher than the average of treatments without metalaxyl. Treatments including metalaxyl were not different from the best treatment in 13 of 24 comparisons and were better than the nonprimed, untreated control for 15 of 24 comparisons. The nonprimed metalaxyl/captan treatment was never grouped with the best treatment and was never different from the nonprimed, untreated control.

Plant height and uniformity. The trial × treatment interaction was significant in the combined ANOVA for plant height; therefore each trial was analyzed separately. Plant height differed among treatments in three of four trials, Urbana in 1992 and 1993 and Vincennes in 1993 (Table 2). In each of those trials, the treatment which produced the tallest plants was not significantly different from primed Ongard/standard fungicide, primed control, primed chlorothalonil, primed fluazinam, primed

Table 2. Effects of seed treatments on plant height of *sh2* sweet corn hybrid Even Sweeter planted in Vincennes, Indiana and Urbana, Illinois in 1992 and 1993

Seed treatments and contrasts	Bioprimed	1992		1993		Treatment mean
		Ind	Ill	Ind	Ill	
Ongard/standard fungicide[a]	Yes	26[b]	19	61	53	38
Standard fungicide	No	20	19	47	42	31
Fluazinam/chlorothalonil	No	22	15	36	44	29
Pseudomonas fluorescens	No	19	16	18	45	26
Untreated control	No	20	14	37	48	29
Addamax	No	13	14	26	40	24
Chlorothalonil	No	19	14	29	47	27
Fluazinam	No	17	16	49	44	29
Imazalil	No	14	13	40	45	31
Metalaxyl	No	20	17	33	47	29
Metalaxyl/captan	No	15	18	29	39	25
Triadimefon	No	18	17	43	44	30
Untreated control	Yes	25	17	52	47	34
Addamax	Yes	21	18	52	41	30
Chlorothalonil	Yes	21	18	56	47	34
Fluazinam	Yes	20	17	46	51	32
Imazalil	Yes	20	18	47	40	30
Metalaxyl	Yes	21	20	45	52	33
Metalaxyl/captan	Yes	19	19	54	57	36
Triadimefon	Yes	22	18	39	46	30
Grand mean		20	17	42	46	
Standard deviation		3.2	1.9	11	5	
BLSD ($k = 100$)[c]		NS	2.6	28.7	11.1	4.4
Contrasts[d]						
No priming		18*[e]	15*	36	44[f]	28*
Priming		21*	18*	50	48	32*
No metalaxyl		20	16*	42	45	29*
Metalaxyl		20	19*	47	48	32*

[a] Standard fungicide treatment applied by Asgrow Seed Company includes thiram, carboxin, captan, metalaxyl, and imazalil.
[b] Mean plant height (cm) measured from 10 plants per experimental unit with three (Vincennes, 1993) or four replicates.
[c] BLSD for comparison among 20 treatments within years and locations.
[d] Contrasts of eight primed vs. eight nonprimed seed treatments, and six treatments including metalaxyl vs. 14 treatments without metalaxyl.
[e] Comparison of contrasts means are significantly different at the 0.01 level if followed by an asterisk (*).
[f] Comparison of primed and nonprimed treatments at Urbana in 1993 was significant at the 0.05 level.

metalaxyl, primed metalaxyl/captan, primed triadimefon, and nonprimed metalaxyl. The Ongard/standard fungicide treatment had the highest mean plant height in two of four trials and had the second and third highest means in the other two trials. Nonprimed Addamax and nonprimed *Pseudomonas fluorescens* were the only treatments for which plants were significantly smaller than those of the tallest treatment in all three trials.

The contrast of primed and nonprimed seed was significant at the 0.01 level in three of four trials and significant at the 0.05 level in the fourth trial (Table 2). Averaged over the eight seed treatments, primed seed produced plants that were 3 to 14 cm taller than nonprimed seed. Unlike plant stands, the seed treatment × priming interaction was not significant when plant height was the dependent variable. Primed Addamax and primed imazalil at Urbana in 1993 were the only primed treatments for which plant height was significantly lower than the best treatment in any of the trials.

The contrast of treatments with and without metalaxyl was significant only for the Urbana trial in 1992. Metalaxyl-treated seed produced plants that were about 3 cm taller than nontreated seed in that trial (Table 2). Uniformity of plant height, measured as the percentage of plants within 2.5 cm of experimental unit means, did not differ except for the trial at Vincennes in 1992 in which 43% of the plants grown from primed seed were within 2.5 cm of plot means, but only 32% of plants grown from nonprimed seed were within that range of uniformity.

Fungi recovered. The fungi most commonly isolated from kernels obtained from all treatments and replicates at 5 and 10 DAP at Vincennes in 1992 were *Pythium ultimum* Trow, *Rhizopus stolonifer* (Ehrenb.:Fr.) Vuill., and *Rhizopus arrhizus* A. Fischer (Table 3). *Trichoderma* spp., *Gliocladium* spp., *Fusarium oxysporum* Schlechtend.:Fr, and *Fusarium moniliforme* J. Sheld. were isolated less frequently. *Penicillium oxalicum* Currie & Thom, often an important pathogen of *sh2* sweet corn, was isolated from less than 1% of the seed.

In 1992, at Vincennes, *Pythium ultimum* was isolated from about 28% of the kernels 5 DAP but from only 7% of the kernels 10 DAP. At Urbana, *Pythium ultimum* was isolated from about 8 and 3% of the kernels 5 and 10 DAP, respectively (Table 3). Cool temperatures, 10–14 C, and wet soils were conducive to growth and infection of fungi such as *Pythium ultimum*. The number of isolations of *Rhizopus* spp. were similar on both dates at Vincennes, but the frequency of isolation of this species increased at Urbana. Isolation of *Trichoderma* spp. was low at Vincennes but relatively high at Urbana. Isolation of *F. moniliforme* on both dates ranged between 4.0 and 4.6% at Vincennes and 2.8 and 4.7% at Urbana in 1992.

In 1993, the soil temperatures were warmer and *Pythium ultimum* could not be isolated from the seed 5 and 10 DAP at the Vincennes trial. The most common fungus, *F. moniliforme,* was recovered from 36 and 30% of the isolations 5 and 10 DAP, respectively (Table 3). Both *R. arrhizus* and *R. stolonifer* were common 5 and 10 DAP in 1993, as in 1992. *Penicillium oxalicum* was isolated more frequently 10 DAP in 1993. Both *Trichoderma* and *Gliocladium* spp. increased significantly by the second sampling date for both years at the Vincennes trial. The increased frequency of these fungi corresponded with higher soil temperatures.

DISCUSSION

The treatments that enhanced stand establishment in this study had the broadest range of activity. Fungicides and other treatments with specific activity improved plant stands and height in various trials, but individual treatments were inferior to combinations of fungicides and seed treatments. For example, solid matrix priming enhanced stands of the untreated control treatment by 8–28%; but stands of the primed, untreated control treatment were always significantly less than those of the best treatment. Thus, our conclusions are an extension of those of Wilson et al (17), who proposed that an effective seed treatment formulation for *sh2* seed should include a protectant fungicide such as captan/thiram, a broad spectrum systemic such as a benzamidazole, and a compound effective against *Pythium* spp., such as metalaxyl. We would add to their proposal that other seed treatments which enhance emergence and growth, such as solid matrix priming or inert polymer seed coating (e.g., Ongard), should be included because they are beneficial in some cases, although certainly not in all instances. A multicomponent seed treatment is a type of insurance, in that a specific component of the seed treatment may be unnecessary and have no effect in many environments, but it may enhance stands and/or growth in others. For example, the Ongard/standard fungicide treatment had superior stands compared to the standard fungicide treatment at Vincennes in 1992, but the two treatments were similar at Urbana in 1993. Unless priming and polymer coatings enhance performance in a substantial number of environments beyond that of standard fungicides, costs of these treatments are a major limitation to their use. Additional trials with several locations and hybrids are needed to test this.

Priming improved stands considerably when added to relatively ineffective seed treatments. Priming gave little additional stand improvement when fungicides were effective, although overall stands of primed treatments were higher than those of nonprimed treatments in most comparisons. The beneficial effect of priming on plant height was much more evident. Apparently, priming improved the speed of seedling emergence and/or early growth of seedlings, although plants from primed seed were no more uniform than those from nonprimed seed. When standard fungicide treatments are ineffective, priming may be an important component of a broad seed treatment.

Because benomyl is no longer registered for use on sweet corn seed, imazalil has been used under an emergency exemption for treatment of seed in Idaho. In three of our four trials, nonprimed imazalil-treated seed had significantly lower stands than the untreated control. Primed, imazalil-treated seed had stands that were not different from the primed, untreated control except for in Urbana in 1993. Wilson et al (17) noted previously that imazalil was not an equivalent substitute for benomyl and usually resulted in slightly lower stands. Additional trials in several environments, similar to those of Wilson et al (17), are needed to determine the selectivity of imazalil on sweet corn.

Table 3. Fungi isolated from germinating kernels of the *sh2* hybrid Even Sweeter collected from the soil 5 and 10 days after planting (DAP) in Vincennes, Indiana and Urbana, Illinois

	Vincennes				Urbana	
	5 DAP		10 DAP		5 DAP	10 DAP
Species	1992	1993	1992	1993	1992	1992
Alternaria sp.	<1[a]	4	0	<1	0	0
Pythium ultimum	28	0	7	0	8	3
Rhizopus arrhizus	35	22	32	20	13	22
Rhizopus stolonifer	23	17	27	13	14	27
Trichoderma sp.	3	5	14	20	52	30
Gliocladium sp.	1	3	2	7	8	8
Fusarium oxysporum	0	0	6	0	3	3
Fusarium moniliforme	4	36	5	30	3	5
Penicillium oxalicum	<1	11	0	5	0	0
Others	8	9	<1	2	0	0

[a]The mean percent total isolations/species; total isolations at Vincennes for 5 DAP = 327 and 10 DAP = 365 for 1992, and 5 DAP = 442 and 10 DAP = 443 for 1993; total isolations at Urbana for 5 DAP = 459 and for 10 DAP = 344.

Apparently *Pythium ultimum* was one of the primary pathogens at both locations in 1992, based on the frequency of isolation and the effectiveness of treatments that included metalaxyl. Due to small sample size, a statistical analysis could not be conducted comparing treatment effects on isolation frequencies. When the data were compared visually, it appeared that *Pythium* was never present in the metalaxyl-containing treatments the first year. In 1993, *F. moniliforme* and *Penicillium oxalicum* were isolated from seed more frequently. These differences in fungi recovered from kernels are indicative of the variety of problems that can limit stands and early growth, and reinforce the proposal of a broad spectrum, multicomponent seed treatment.

The relatively poor stands of Even Sweeter (ranging from 2 to 79%) that occurred in our trials are similar to the stands (ranging from 18 to 82%) reported by Wilson et al (17) for a similar white *sh2* hybrid, SummerSweet 8701. While fungicide treatments, priming, polymer coatings, and other seed treatments may improve the stands of these hybrids to some extent, substantial improvements can be made by developing *sh2* lines that are genetically superior for cold tolerance, germination, emergence, and resistance to seed and soilborne pathogens.

LITERATURE CITED

1. Bennett, M. A., and Waters, L. Y. 1987. Germination and emergence of high-sugar sweet corn is improved by presowing hydration of seed. HortScience 22:235-238.
2. Bradford, K. J. 1986. Manipulation of seed water relations via osmotic priming to improve germination under stress conditions. HortScience 21:1105-1112.
3. Callan, N. W., Mathre, D. E., and Miller, J. B. 1990. Bio-priming seed treatment for biological control of *Pythium ultimum* pre-emergence damping-off in *sh2* sweet corn. Plant Dis. 74:368-372.
4. Cohn, M. A., Obendorf, R. L., and Rytko, G. T. 1979. Relationship of stelar lesions to radicle growth in corn seedlings. Agron. J. 71:954-958.
5. Featonby-Smith, B. B., and Van Staden, J. 1983. The effect of seaweed concentrate and a fertilizer on the growth of *Beta vulgaris*. Z. Pflanzenphysiol. 112:115-162.
6. Finnie, J. F., and Van Staden, J. 1985. Effect of seaweed concentrate and applied hormones on in vivo cultured tomato roots. J. Plant Physiol. 120:215-222.
7. Goatley, J. M., Jr., and Schmidt, R. E. 1991. Biostimulator enhancement of Kentucky bluegrass sod. HortScience 26:254-255.
8. Herner, R. C. 1986. Germination under cold soil conditions. HortScience 21:1118-1122.
9. Juvik, J. A., Jangula, M. C., Headrick, J. M., Pataky, J. K., and Tracy, W. F. 1993. Kernel changes in shrunken-2 maize population associated with selection for increased field emergence. J. Am. Soc. Hortic. Sci. 118:135-140.
10. Kubik, K. K., Eastin, J. A., Eastin, J. D., and Clegg, M. D. 1992. Supersweet sweet corn: Combining solid matrix priming (SMP), with microbial seed inoculation. Natl. Sympos. Stand Estab. Hortic. Crops. C. Vavrina, ed. Univ. Fla. Proc. 101:139-147.
11. Lawrence, E. B., Nelson, P. E., and Ayers, J. E. 1981. Histopathology of sweet corn seed and plants infected with *Fusarium moniliforme* and *Fusarium oxysporum*. Phytopathology 71:379-386.
12. Nelson, W. R., and Van Staden, J. 1984. The effect of seaweed concentrate on growth of nutrient-stressed greenhouse cucumbers. HortScience 19:81-82.
13. Schmidt, D. H., and Tracy, W. F. 1988. Endosperm type, inbred background, and leakage of seed electrolytes during imbibition in sweet corn. HortScience 23:269-272.
14. Styer, R. C., and Cantliffe, D. J. 1984. Dependence of seed vigor during germination on carbohydrate source in endosperm mutants of maize. Plant Physiol. 76:196-200.
15. Styer, R. C., Cantliffe, D. J., and Hannah, L. C. 1980. Differential seed and seedling vigor in shrunken-2 compared to three other genotypes of corn at various stages of development. HortScience 105:329-332.
16. Wilson, D. O., Jr., and Mohan, S. K. 1992. Effect of seed moisturization and fungicide treatment on final stand of low vigor shrunken-2 sweet corn inbreds. J. Prod. Agric. 5:510-512.
17. Wilson, D. O., Jr., Mohan, S. K., Knott, E. A., and Shafii, B. 1993. Evaluation of fungicide seed treatments for *shrunken-2* "Supersweet" sweet corn. Plant Dis. 77:348-351.